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Radial non-uniform piezoelectric response of perovskite islands in thin PZT films

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The structural, ferroelectric and piezoelectric properties of thin polycrystalline $Pb(Zr,Ti)O_3$ (PZT) films grown by RF magnetron sputtering have been studied. The films were fabricated in two stage process on $Pt/TiO_2/SiO_2/Si$ substrate. At the first stage, films were deposited at low substrate temperatures (~150 °C) and, at the second stage, ones were annealed and crystallized into perovskite phase at 530-570°C in the conventional furnace. The film thickness was 500 nm.

Microstructure of the films was studied using scanning electron microscope EVO-40 and atomic force microscope MFP-3D SA, Asylum Research and Ntegra Prima. Piezoelectric contact mode (applied alternative voltage 5 V) was used to fix piezoelectric response in the films under study.

Composition of the films corresponded the morphotropic phase boundary with elemental ratio of Zr/Ti = 53.5/46.5. X-ray diffraction results have shown a well-defined <110>- perovskite texture. Microstructure is characterized by spherulite blocks of 10-40 μm in size, according to annealing temperature.

The morphology of the surface and the piezoelectric effect of individual perovskite islands was studied. It was shown the solid-state phase transformation of pyrochlore-perovskite is accompanied by relaxation of mechanical stresses at the interface.

The effect of inhomogeneous distribution of the piezoresponse over the surface of the perovskite island (Fig. 1) - from the maximum response near its boundary to the minimum - to the center of the island was found. It is assumed that the observed effect is caused by the difference in the mechanical clamping of the crystal grains in the periphery of the islets and in the center.

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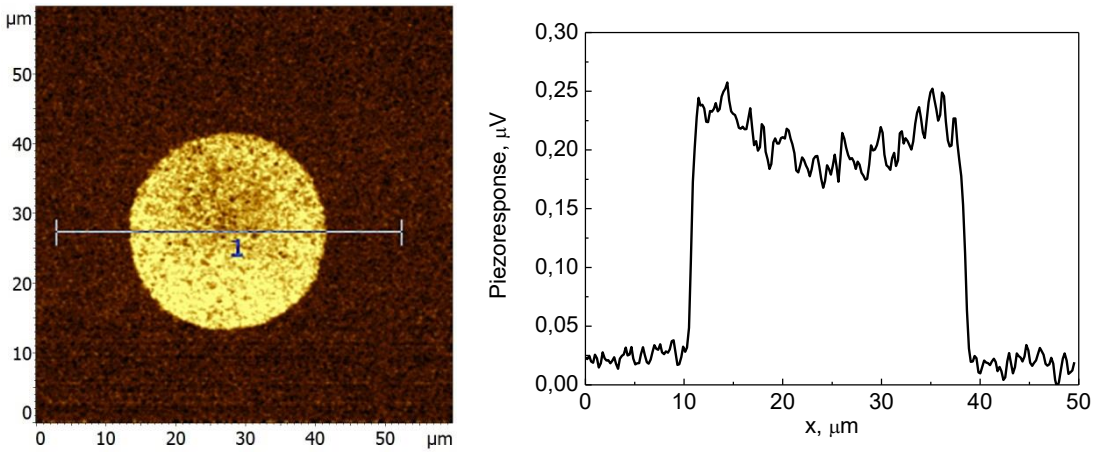

Figure 1. PFM image and profiles of the piezoelectric response of the perovskite island.